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Identification tag with environmental sensing facility

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Abstract

A radio frequency identification tag 1 which is energised by a radio signal from a reader station 11 to transmit a code identifying the tag. The tag incorporates a sensor 7 responsive to an environmental parameter 8 to which the tag is exposed, and when the tag is energised by an adjacent reader the radio signal returned to the reader includes a code representing a measurement value corresponding to an output of the sensor. Thus the tag not only identifies the item to which it is attached, but also provides a measurement of the parameter to which the sensor is responsive. The measurement may be the instantaneous output of the sensor or a stored output, for example the maximum or minimum temperature to which the sensor has been exposed.

Description

RADIO FEBE QUENCY IDENTIFICATION TAG
The present invention relates to radio frequency identification tags.

Radio frequency identification (RFID) tags (or transponders) are electronic devices which store identification codes and transmit the codes when interrogated by a radio frequency electromagnetic signal. A tag attached to an object, animal or person allows an ambiguous and convenient identification of that to which it is attached, and the tag may be used for identification purposes without requiring any action on the part of the person, animal or object carrying the tag to trigger the identification process. For example it is not necessary to present a card or label such as a bar code label to a reader. The tags do not incorporate an on-board power source but rather incorporate a power supply, generally a charge storage capacitor, that is energised by low power radio signals which are also used for the transmission of data in both directions between the tag and a reader intended for use with that tag.

Known tags are highly integrated devices that contain a small number of electronic components, usually sealed in a plastics case or glass capsule. A tag can be as small as a grain of rice or as large as a ice hockey puck. Regardless of their size, the characteristics of RFID tags can be summarised as follows: 1. Tags are generally designed for use with a dedicated electronic unit or
"reader", although readers are now available which are self-programmable so as to be capable of communicating with a wide range of different tags. In all cases the reader transmits a coded radio signal through a small antenna into the environment in which tags are to be detected.

2. Each tag incorporates its own antenna and when it is sufficiently close to a reader (generally within about two metres dependant upon the size of the tag) the tag is energised by the radio signal transmitted by the reader. When a tag is out of range of a reader, it remains inert.

3. The tag stores an identification code in a non-volatile memory and when energised generates a coded radio signal incorporating the stored code and transmits the radio signal through its antenna.

4. The reader detects signals transmitted by any adjacent tag, demodulates the coded data message incorporated in the signal received from the tag, verifies the accuracy of the information by using appropriate communications protocols, and then delivers the decoded information to an appropriate output, for example by transmitting a message to a computer for interpretation and action.

The known RFID tags offer significant advantages in performance when compared with other identification technologies such as bar codes. For example, with
RFID tags, there is no line of sight requirement for reading or writing data; tags provided with programmable memories may be reprogrammed in-situ, using the same low power radio signals as are used during the reading process; if desired tags can be programmed with a

permanent identification code; tags can be attached to, or buried in, most non-metallic materials with no effect on performance; they are mechanically robust and are not affected by surface damage; they can be encapsulated so as to withstand chemical attack; they can withstand wide ranges of temperatures; error check coding can ensure very high reliability during the read and write processes; they can be read in all or most orientations assuming careful antenna design; and they cannot be easily replicated. As a result of these advantages, RFID tags are produced in large quantities by a number of suppliers. As an established technology benefiting from advances in the field of electronics which have resulted in rapidly reducing component costs, RFID tags are being used in an ever increasing number in an ever increasing range of applications. It has not previously been suggested however that
RFID tags should be provided with capabilities over and above the basic capability of identifying the individual tags.

It is well known to incorporate sensors of various types into manufactured products. For example, temperature indicating sensors are used in the food distribution industry to indicate the instantaneous temperature of food products, and in some cases to indicate the temperature "history" of food products. It is known for example to incorporate temperature indicating devices in frozen foods which indicate it those foods have ever been allowed to thaw and then been refrozen.

It is an object of the present invention to enable the expansion of the market in which RFID tags can be used by building further capability into such tags.

According to the present invention, there is provided a radio frequency identification tag comprising a power supply, means responsive to a radio signal for energising the power supply, a memory circuit storing a tag identification code, and means energised by the power supply for transmitting from the tag a radio signal representing the tag identification code, wherein the tag further comprises a sensor responsive to an environmental parameter to which the tag is exposed, and means energised by the power supply for generating a sensor code representing the value of the parameter to which the sensor is responsive, the radio signal transmitted from the tag representing the tag identification code and the sensor code.

Thus the present invention proposes the combination of conventional RFID technology with a sensor to allow the remote reading of both the identity of an article to which the tag is attached and the value of a physical parameter to which the tag is exposed. Such parameters might include analog signals, for example temperature, flow rate, pressure, blood sugar levels and the like, or digital signals, for example the state (make or break) of switch contacts. The invention therefore allows remote, unpowered measurement of a wide variety of physical parameters, at a precise physical location, the source of the measurement being identified by the corresponding tag identification number. Sensors may generate an output representing the instantaneous value of the parameter to which they are responsive, but with relatively limited software and/or hardware development would be capable of more sophisticated functions, for example indicating when read whether or not the tag has ever been exposed to an unacceptable condition, for example that the tag has been subjected to a temperature greater or less than a pre-set value.

Tags may be pre-programmed by for example burning in data into a read only memory, or may have non-volatile programmable memory. For example, data may be written to a programmable memory to adjust a programmed set-point.

Reprogramming can be effected without it being necessary to have physical access to or even line of sight contact with the tag.

The tag may incorporate an interface coupled to a resonant circuit tuned to a frequency to which the tag is to be responsive. The interface may comprise a rectifier for converting an AC

signal induced in the resonant circuit to a DC output voltage, and a charge storage device coupled to the output of the rectifier. The interface may comprise a clock circuit for generating a clock signal from signals induced in a coil in the resonant circuit, a demodulator for demodulating data from signals induced in the coil, and a modulator for modulating data derived from the sensor on the memory and a radio signal which is applied to the coil for transmission. A logic circuit may control reading data from the memory to the interface, writing data from the interface to the memory, and reading data from the sensor to the interface. All of the individual circuit components will be powered from the common power supply, data being transferred between components in accordance with a pre-programmed routine determined by the logic circuit.

An embodiment of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:
Figure 1 is a schematic representation of an embodiment of the present invention; and
Figure 2 is a schematic representation of components incorporated in an interface of Figure 1.

Referring to the drawings, a tag 1 is shown within an area 2 which represents the environment to which the tag is exposed. The area 2 could be a physical structure, for example an article within which the tag is embedded, or simply an area of free space within which the tag is located. Incorporated within the tag is an integrated circuit 3 incorporating active circuit components in the form of an interface 4, control logic 5, a memory 6, and a sensor 7. The sensor is responsive to a parameter of the environment within which the tag is located, for example the temperature of that environment. The physical parameter to which the sensor 7 is exposed is represented by arrow 8.

The interface is coupled to the outside world by a coil 9 which forms a tuned resonant circuit with a capacitor 10. The resonant frequency of the circuit is selected to match the frequency of signals transmitted from a reader device 11 via an antenna 12. The reader device outputs a signal which serves two purposes, that is the transmission of energy to the tag assuming that the tag is within its normal operating range, and the transfer of data which both controls the responses of the tag and enables the memory of the tag to be appropriately programmed. The memory 6 is a
ROM or EEPROM access to which is controlled by the logic circuit 5. The antenna 12 also serves to pick up radio signals transmitted from the coil 9, those radio signals being modulated with data which is to be read by the reader.

Figure 2 shows components of the interface 4 and supporting elements in greater detail. The alternating voltage appearing across the capacitor 10 is applied to a rectifier 13 the DC output of which is applied to a charge storing capacitor 14. The voltage across the capacitor serves as the power supply for all the active devices in the tag. RF signals detected by the coil 9 are demodulated by an RF demodulator 15, a clock signal is generated by a clock extract circuit 16 from the fundamental or modulated frequency of the signals transmitted from the reader, and an RF modulator 17 is provided to modulate an RF signal with data from the control logic circuit, the modulated signal being transmitted via the coil 9.

The system described above may use any of the existing transmission schemes currently employed for passive tags. Transmission frequencies can be of relatively high frequency, such as 2.45GHz or 915MHz, or of relatively low frequency such as the range 50kHz to 250kHz.

Similarly the modulation schemes for transmission of data to and from the tag may be any of those typically used in passive tags, for example Amplitude Shift
Keying (ASK), Frequency Shift Keying (FSK) or Phase Shift Keying (PSK).

Encoding of the data stream prior to modulation is typically performed using protocols such

as NRZ (non-return to Zero), Manchester encoding or Coded Di-Phase.

The later schemes help to prevent the development of DC offsets in the tag and receiver circuits and also allow the recovery of a synchronisation clock. The recovered clock is usually essential to distinguish each bit reliably.

A reliable anti-contention protocol may be implemented to permit the detection and operation of several tags within one read volume.

The system components described above could be programmed to operate in a variety of different ways. For example, the reader could be programmed to periodically transmit an interrogation signal to which any in range tag would respond by transmitting back to the reader its characteristic identity code or other information.

The reader would then respond to identification of the tag by transmitting an interrogation signal to read from the memory 6 the data representing the output of the sensor 7. The sensor output would then be received by the reader and associated with the respective tag code. The logic circuit could also be programmed to record for example the maximum and minimum temperatures to which the sensor 7 has been exposed and to transmit appropriate temperature indicating codes to the reader when interrogated.

The present invention has great potential as it is capable of application to the measurement of many different physical parameters in circumstances where it is very important to be able to accurately identify the source of a parameter measurement as well as the measurement value itself. For example, a pressure sensor could be used to simply measure a local pressure whose location is associated with a tag identification number. Pressure measurements in difficult or hazardous circumstances could then be achieved given that direct access to the sensors is not necessary. Measurement values derived from the tags could be logged in association with the tag identities. Thus for example if a series of tags was attached along a length of underground pipe and each incorporated a temperature sensor, an inspector interested in local temperature readings would be able to walk above ground along the course of the pipe and read the temperature at every location of a tag and identify the position from which the sensed measurements originate by reference to the tag identification codes. It will be appreciated that similar applications arise where the parameter of interest is for example pressure or flow rate. Similarly, a simple pressure sensor could be used in an identification tag which would identify if a package within which the tag was positioned had ever been opened, assuming such opening would result in at least a short term pressure fluctuation. Such a system would have great value in food distribution, for example security seals for bottles or containers, and customs inspection, for example for bonded packages, given that large numbers of items could be tagged and scanned automatically with no line of sight or contact requirements at acceptable costs.

By incorporating appropriate anti-contention protocols, it would be possible to read multiple tags simultaneously and therefore it would not be a problem if more than one tag was within range of a reader at any one time. Each tag would in many circumstances only be responsive to a single physical parameter, but for some applications it would be appropriate to incorporate two or more sensors in each tag so that each sensor would be able to sense more than one parameter. Thus a tag might incorporate sensors responsive to say pressure and humidity, acceleration and stress/strain, luminosity and magnetic field strength, chemical or gas concentrations or any other combination of physical conditions. A tag may also incorporate a low power non-volatile display to display user-defined information.

Claims

CLAIMS

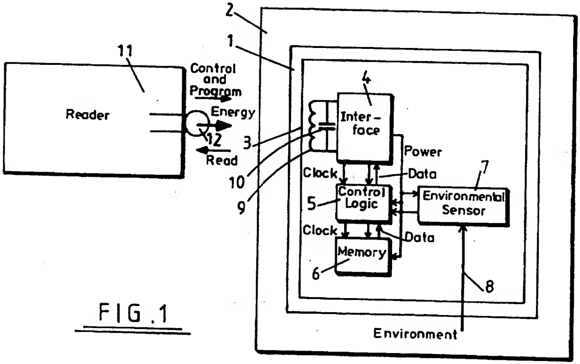
1. A radio frequency identification tag comprising a power supply, means responsive to a radio signal for energising the power supply, a memory circuit storing a tag identification code, and means energised by the power supply for transmitting from the tag a radio signal representing the tag identification code, wherein the tag further comprises a sensor responsive to an environmental parameter to which the tag is exposed, and means energised by the power supply for generating a sensor code representing the parameter to which the sensor is responsive, the radio signal transmitted from the tag representing the tag identification code and the sensor code.

2. A radio frequency identification tag according to claim 1, wherein the radio frequency responsive means comprises an interface coupled to a resonant circuit tuned to a frequency to which the tag is to be responsive, the interface comprising a rectifier for converting an AC signal induced in the resonant circuit to a DC output voltage, and a charge storage device coupled to the output of the rectifier.

3. A radio frequency identification tag according to claim 2, wherein the interface comprises a clock circuit for generating a clock signal from signals induced in a coil of the resonant circuit, a demodulator for demodulating data from signals induced in the coil, and a modulator for modulating data derived from the sensor and the memory on a radio signal which is applied to the coil for transmission.

4. A radio frequency identification tag according to claim 3, comprising a logic circuit which controls reading data from the memory to the interface, writing data from the interface to the memory, and reading data from the sensor to the interface.

5. A radio frequency identification tag substantially as hereinbefore described with reference to Figures 1 and 2 of the accompanying drawings.



2
1
11
Reader
Control
and
Program
Energy
12
Read
3
10
9
4
Inter-
face
Power
Clock
Data
7
Control
Logic
Environmental
Sensor
5
Clock
Data
Memory
6
8
Environment

FIG.1

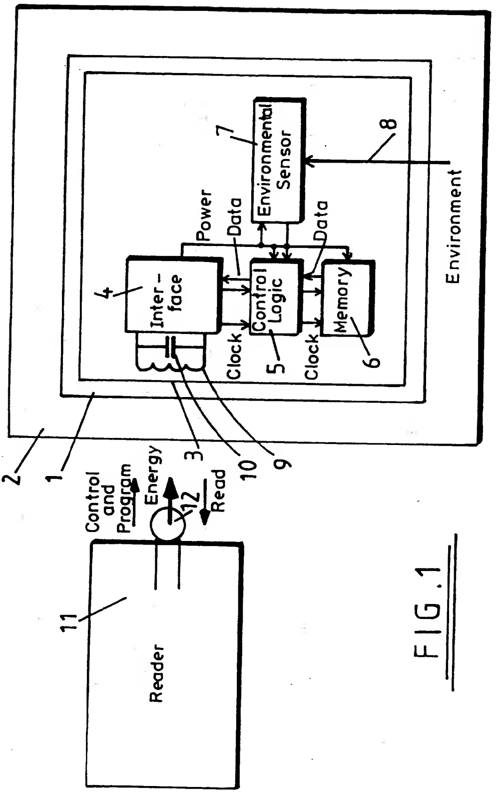

Environmental Sensor
Power
Data
Inter-face
Control Logic
Memory
Clock
Clock
Data
Environment
Reader
Control and Program
Energy
Read
1
2
3
4
5
6
7
8
9
10
11
12

FIG.1

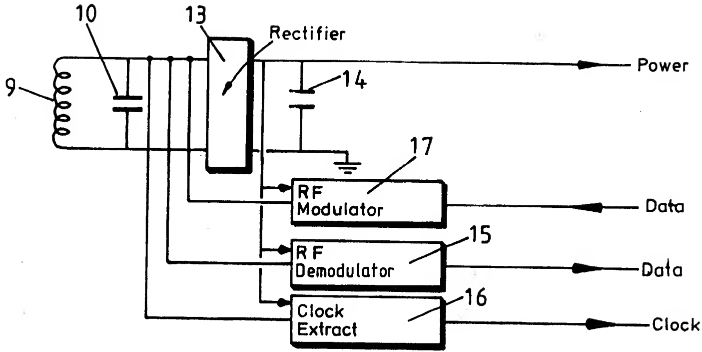

10
13
Rectifier
9
14
Power
17
RF
Modulator
Data
15
RF
Demodulator
Data
16
Clock
Extract
Clock

FIG. 2